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Disturbance periods of interplanetary space caused by CMEs (Preconditioning of IP space)

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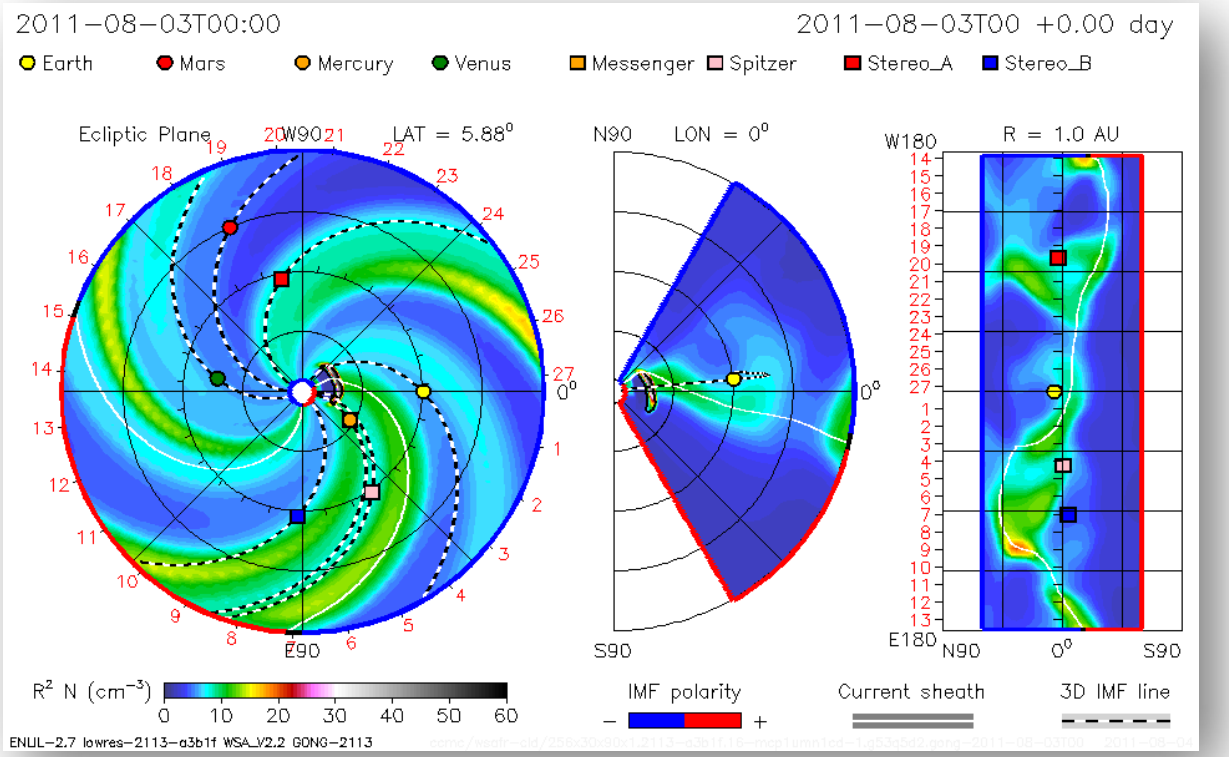
Preconditioning of IP space – when the solar wind behaves differently

Odstrcil et al., 2012 (EGU 2012); see also Lee et al., 2015

CME occurrence rate: 0.3/d (solar min) to 4-5/d (solar max) (e.g., St. Cyr et al., 2000, Gopalswamy et al., 2006).

CME transit time from Sun to 1AU: 1 to 4 days (average speed: 500 km/s with max. speeds up to 3000 km/s).

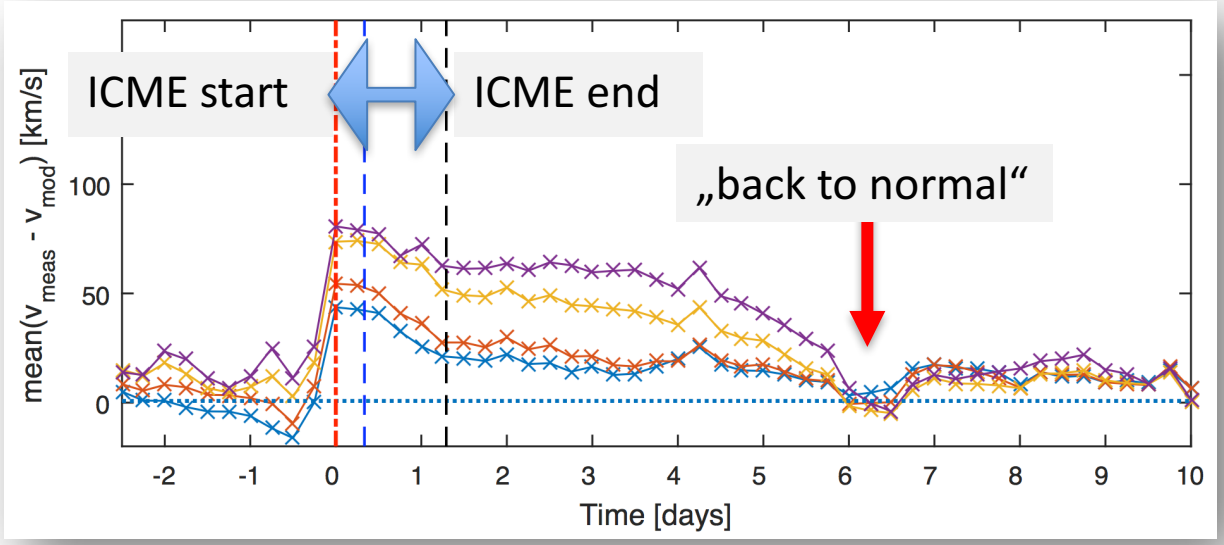
Preconditioning of IP space = a Space Weather parameter!



During times of inreased solar activity preconditioning prevails and let Space Weather forecasting models fail (see e.g., Gressl et al., 2014). Understanding the short-term variations in the structuring of IP space will lead us finally to understand CME propagation behavior.

How to quantify „disturbed conditions“!?

We use ideal models simulating the solar wind (SW) plasma speed at a target where actual in situ measurements are available (L1). The ideal SW models simulate the quiet background SW without transient events, i.e., CMEs. Statistical analysis between modeled and observed, hence including CMEs, SW speed showed: Disturbed SW conditions caused by CMEs prevail over ca. 3 and up to 6 days after the ICME start, which is much longer than the average duration of an ICME disturbance itself (~1.3 days).



=> IP space needs about 2–5 days to recover from the impact of ICMEs.

Temmer et al., (2017)

Discussion

Super-fast CME from July 23, 2012 (Sun-1AU in less than 21hrs!) might be explained by our results. Preconditioning of IP space due to an earlier CME event from July 19, 2012 (Liu et al., 2014; Temmer and Nitta, 2015).

But how are such specific long-lasting disturbance periods of 3 – 6 days caused?

1. Does this period reflect the recovery time of the entire system, i.e., the interplanetary medium, which needs to relax from the evolving disturbance?
2. Is it caused by multiple CME eruptions? We checked that and removed the „chains of CME events“ from the statistical sample: the same trend of prolonged disturbance periods was found.
3. This maybe hints to other kind of disturbances, or nonlisted ICMEs, traveling in the wake of the listed ICMEs (we used the R&C list for our study) – the source of it might be found in the solar wind evolution itself and/or the reaction of the solar corona on large-scale restructuring due to CMEs.

DBM results for the event studies

http://swe.uni-graz.at/index.php/services/cme-forecast
Vrsnak and Zic, 2007; Vrsnak et al., 2014; Zic, Vrsnak, Temmer, 2015

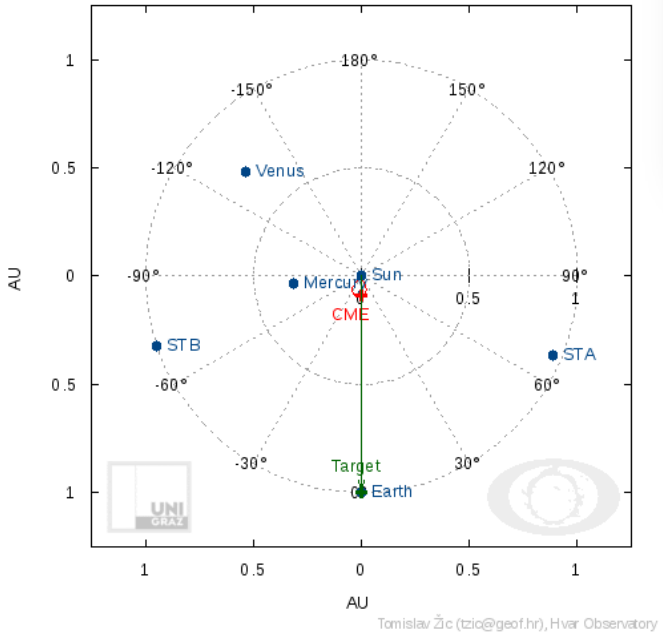
A) 3 April 2010 10:33 UT (hit)
B) 15 March 2013 07:12 UT (hit)
C) 15 March 2015 01:48 UT (hit; problematic, many models predict a late arrival)
D) 7 January 2014 18:24 UT (false alarm; only a weak discontinuity arrives)

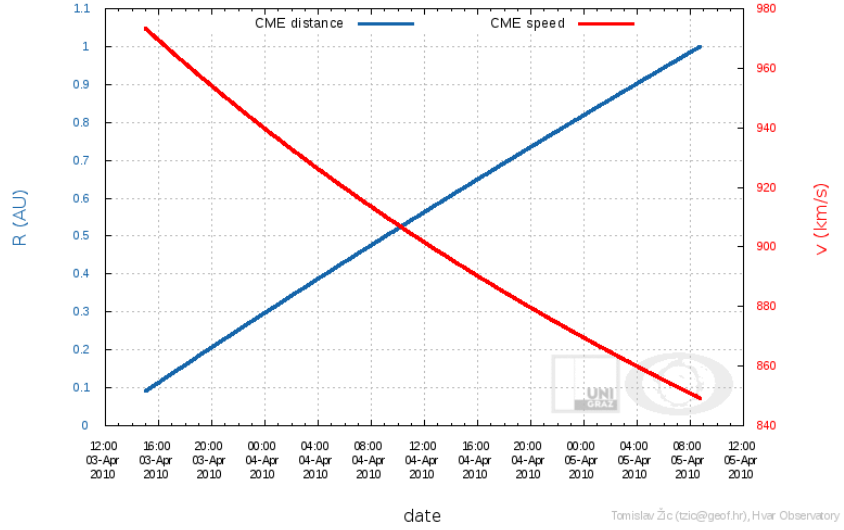
April 3, 2010 – April 5, 2010

DBM results

results.txt — Bearbeitet

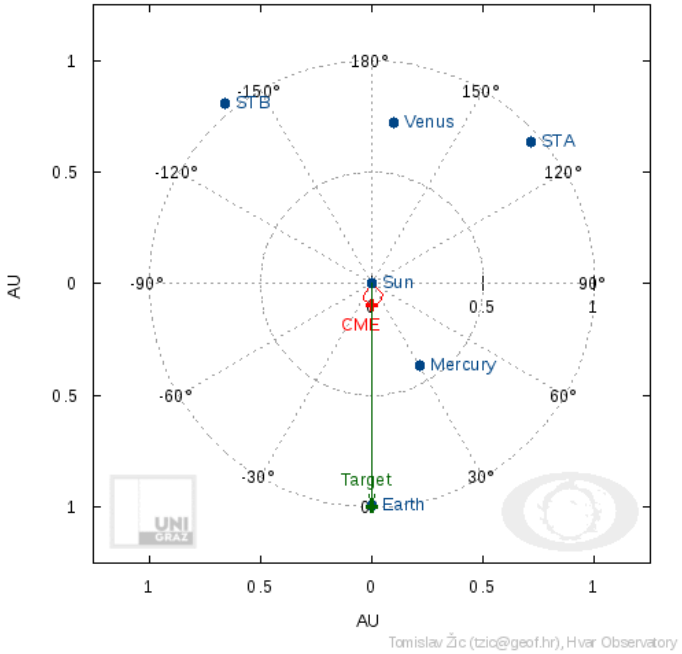
Does CME hit target?	Hits
CME take-off date & time (UT)	2010-4-3 15h:0min
Drag parameter gamm (10^-7*km^-1)	0.05
Solar wind speed, w (km/s)	500.00
Starting CME radial distance, R0 (rSun)	20.00
CME speed at R0, v0 (km/s)	1000.00
CME's angular half-width, lambda (deg)	30.00
Source region central meridian distance, phiCME (deg)	-10.00
Longitudinal separation to target, phitar (deg)	0.00
Radial distance in ecliptic to target, Rtarget (AU)	1.00
CME arrival date & time (UT) at target position	2010-4-5 8h:44min
CME travel time, T (h)	41.74
CME transit speed, vT (km/s)	849.20





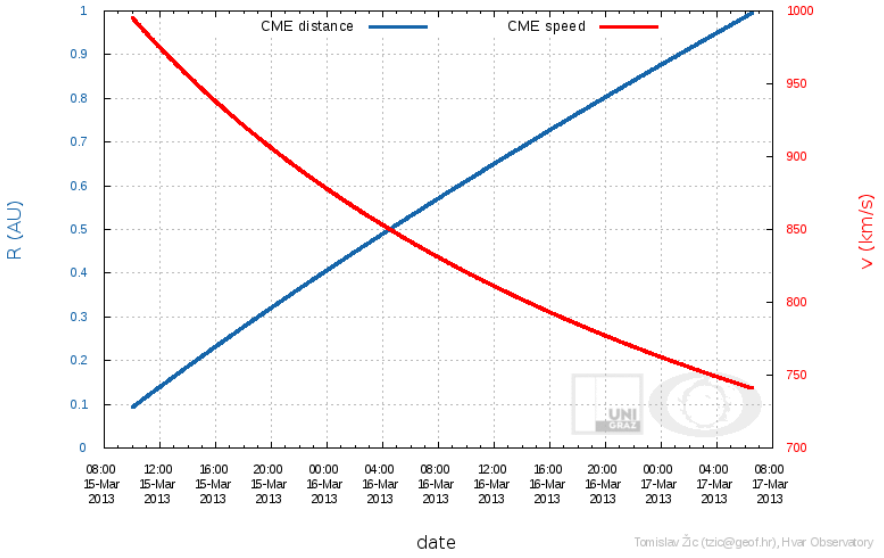
March 15, 2013 – March 17, 2013

DBM results



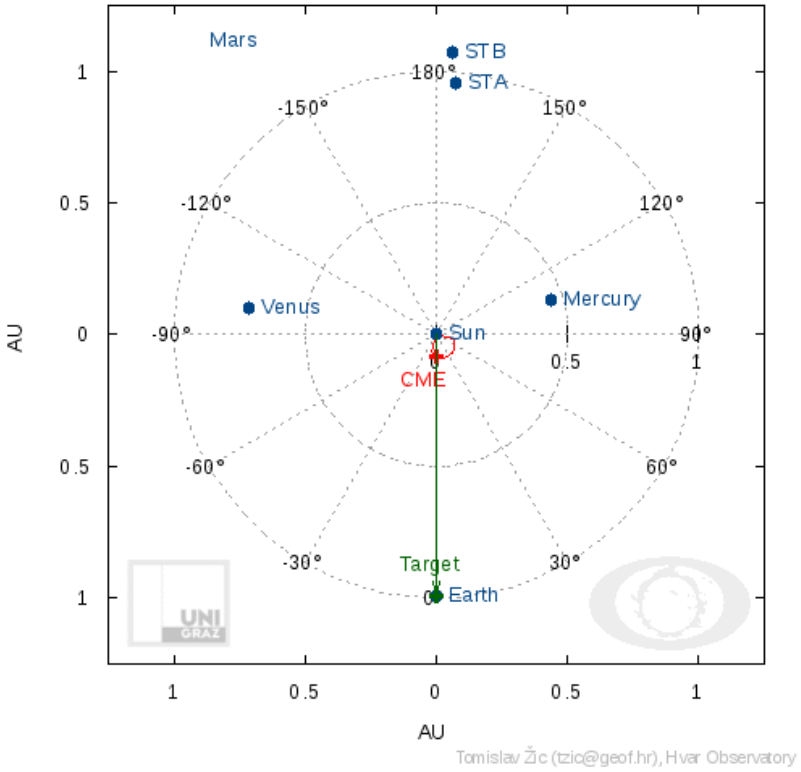
results.txt — Bearbeitet

Does CME hit target?	Hits
CME take-off date & time (UT)	2013-3-15 10h:0min
Drag parameter gamm (10^-7*km^-1)	0.10
Solar wind speed, w (km/s)	450.00
Starting CME radial distance, R0 (rSun)	20.00
CME speed at R0, v0 (km/s)	1000.00
CME's angular half-width, lambda (deg)	40.00
Source region central meridian distance, phiCME (deg)	5.00
Longitudinal separation to target, phitar (deg)	0.00
Radial distance in ecliptic to target, Rtarget (AU)	1.00
CME arrival date & time (UT) at target position	2013-3-17 6h:30min
CME travel time, T (h)	44.51
CME transit speed, vT (km/s)	741.07



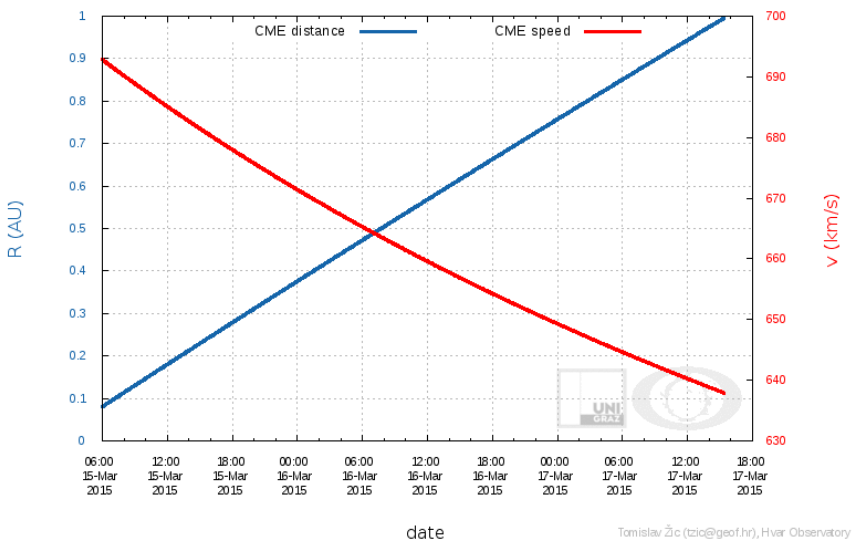
March 15, 2015 – March 17, 2015

DBM results



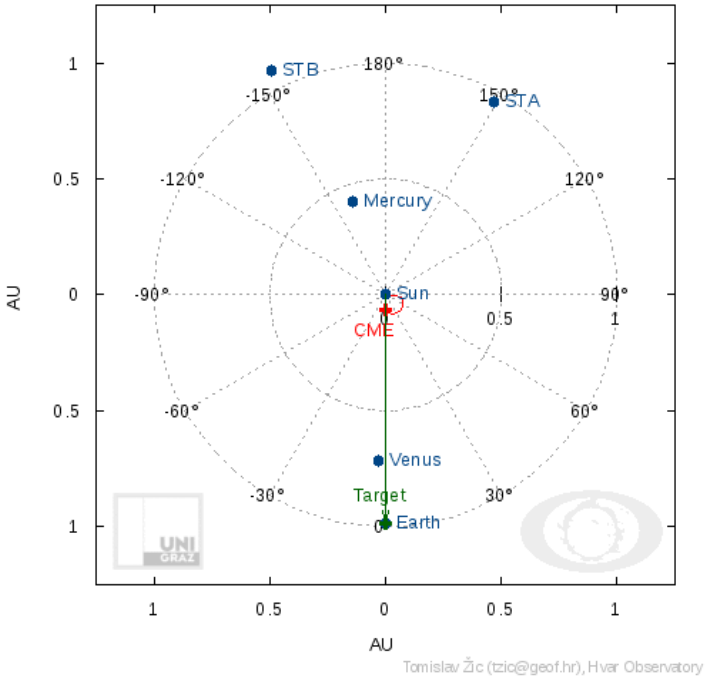
results.txt — Bearbeitet

Does CME hit target?	Hits
CME take-off date & time (UT)	2015-3-15 6h:0min
Drag parameter gamm (10^-7*km^-1)	0.10
Solar wind speed, w (km/s)	500.00
Starting CME radial distance, R0 (rSun)	20.00
CME speed at R0, v0 (km/s)	800.00
CME's angular half-width, lambda (deg)	45.00
Source region central meridian distance, phiCME (deg)	30.00
Longitudinal separation to target, phitar (deg)	0.00
Radial distance in ecliptic to target, Rtarget (AU)	1.00
CME arrival date & time (UT) at target position	2015-3-17 15h:19min
CME travel time, T (h)	57.33
CME transit speed, vT (km/s)	637.93



January 7, 2014 – January 9, 2014

DBM results



results.txt — Bearbeitet

Does CME hit target?	Hits
CME take-off date & time (UT)	2014-1-7 20h:0min
Drag parameter gamm (10^-7*km^-1)	0.10
Solar wind speed, w (km/s)	450.00
Starting CME radial distance, R0 (rSun)	20.00
CME speed at R0, v0 (km/s)	1800.00
CME's angular half-width, lambda (deg)	40.00
Source region central meridian distance, phiCME (deg)	40.00
Longitudinal separation to target, phitar (deg)	-0.00
Radial distance in ecliptic to target, Rtarget (AU)	0.98
CME arrival date & time (UT) at target position	2014-1-9 9h:57min
CME travel time, T (h)	37.95
CME transit speed, vT (km/s)	838.42